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AGRICULTURAL MEMORANDUM NO. 405

# A TRIAL OF THE HARTLEY INTEGRATING THERMOMETER

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## THE INSTRUMENT

The Hartley Integrating Thermometer (see attached diagram) consists of a closed glass tube in which a bubble moves upwards in a viscous liquid. The rate of movement is determined by the viscosity, a function of temperature, and by a restricting capillary which controls the sensitivity. The position of the bubble, which acts as on index on a linear scale, is read as the mean of the locations of the top and bottom menisouses. Since the relationship between displacement (mm per day) and average temperature is non-linear, a calibration curve is supplied.

Obvious benefits of the integrating thermometer are that it is a cheap, self-contained unit which does not require recharging and the only field measurement required is one of linear displacement. In situations where the temperature is fairly constant or where a record of the extremes is not required, for example, in glasshouses or animal houses, it appears to offer an alternative to the thermograph and maximum and minimum thermometers for the measurement of average temperature. It would however need to be screened from direct solar radiation as indeed do the other instruments mentioned.

## THE TRIAL

The instruments were set up in a standard Stevenson Screen and read daily (not weekends) generally between 0730 and 0800 G.M.T. Comparisons of average temperature were usually made on a six day basis and twelve results were obtained. (A thermograph was not used for the first three weeks). The results are set out below.

| Period 1971 (all dates inclusive) | Bubble Displacement mm/Day | Average Temperature °C | | |
|---|---|---|---|---|
| | | From Calibration Curve | Max. and Min. | Thermograph |
| 23/2 - 1/3 | 3.20 | 5.0 | 5.0 | |
| 2/3 - 8/3 | 2.20 | 1.5 | 1.8 | |
| 16/3 -22/3 | 3.67 | 6.5 | 6.0 | |
| 23/3 -29/3 | 3.67 | 6.5 | 6.1 | 6.7 |
| 30/3 - 5/4 | 3.67 | 6.5 | 5.9 | 5.9 |
| 6/4 -13/4 | 4.00 | 7.2 | 6.9 | 6.6 |
| 14/4 -19/4 | 4.00 | 7.2 | 7.2 | 7.1 |
| 27/4 - 3/5 | 4.00 | 7.2 | 6.5 | 5.5 |
| 4/5 -10/5 | 6.80 | 12.7 | 12.5 | 12.2 |
| 11/5 -14/5 | 7.33 | 13.6 | 14.5 | 14.2 |
| 21/6 -28/6 | 7.43 | 13.8 | 14.2 | 13.5 |
| 29/6 - 5/7 | 9.00 | 16.0 | 15.6 | 15.4 |
| | Mean 23/2 - 5/7 | 8.6 | 8.5 | |
| | Mean 23/3 - 5/7 | 10.1 | 9.9 | 9.7 |

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For each period for which an average temperature has been estimated, the value obtained from the integrating thermometer would appear to be adequate for most practical purposes. The variance of the average temperatures over the periods between 23/2 to 5/7 for each of the ~~two~~ three methods of estimation are not significantly different (5% level).

A comparison of the period means using the 't' test

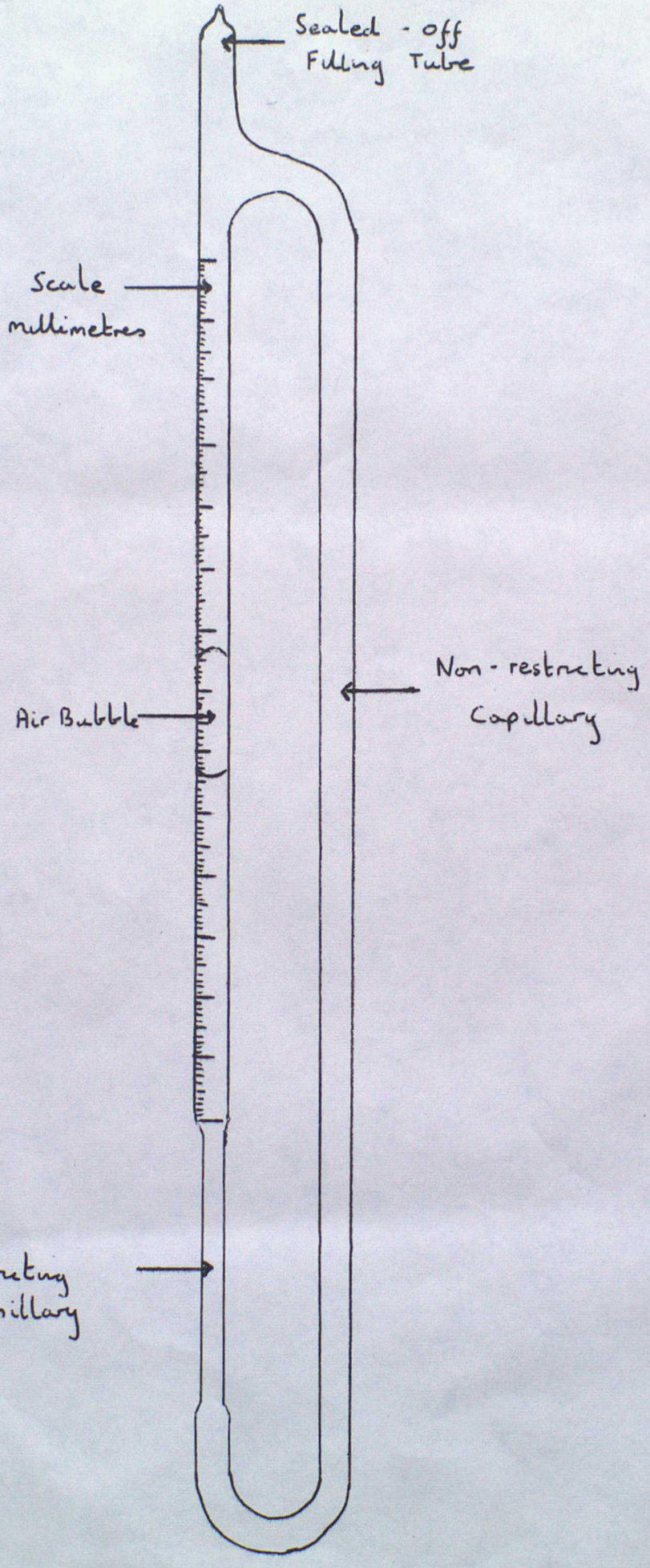
| | | | | | |
|---|---|---|---|---|---|
| gives | t = 0.02 | Hartley | vs. | Max. & Min. | (23/2 - 5/7) |
| | t = 0.21 | Hartley | vs. | Thermograph | (23/3 - 5/7) |

ie is not significant at any level.

Some difficulty arose when trying to reset the bubble, when it has reached the end of the scale. The suggested method, warming to 50°C and shaking the bubble to the other end of the tube, did not work. In the end the thermometer was suspended, upside down, over the radiator for a few days. For practical purposes it would be better to have two or more thermometers used in rotation. Alternatively, since the thermometer is a constant flow system with the restriction as the controlling factor, there seems to be no good reason why it cannot be inverted and readings taken as the bubble retreats back up the scale. This is currently being tested.

## CONCLUSION

The integrating thermometer is a compact, well designed instrument which is both easy to use and maintain. The results compare favourably with those arrived at by using traditional methods of recording average temperature but it gives no indication of the temperature extremes. However, the integrating thermometer currently costs about £4 compared with about £40 for a thermograph and £6 each for maximum and minimum thermometers.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Restricting
Capillary

ACTUAL SIZE